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FACTORS INVOLVED IN THE DEVELOPMENT OF PATHOLOGICAL BEHAVIOR: SCHIZOKINESIS AND AUTOKINESIS

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In spite of the enormous amount of biochemical and physiological data accumulated on the study of abnormal behavior, we do not yet have a comprehensive answer to the mechanism of its development. However, certain leads discovered by the application of objective methods used by Pavlov help us to an insight into this problem. I shall describe especially what light is thrown upon experimental neurosis by our studies of the use of the cardiac conditional reflex, as we have evolved it during the past two decades.

Study of the cardiac factor (emotional background) in normal and abnormal behavior has revealed mechanisms hitherto unknown in the development of experimental neurosis. A study of the dog over his life span, up to fifteen years, in this laboratory, as well as the previous work of Pavlov, has shown that both the external and internal environments and the genotype (temperament) play a role.

Pavlov gave equal emphasis to the factors of the internal and external environment. Although he recognized the importance of ordinary emotional stimuli, he was especially concerned with what he called conflict or collision between the excitatory and the inhibitory conditional reflexes. His previous work convinced him that the activity of the nervous system at the higher levels could be expressed in terms of excitation and inhibition similar to what was known in neurophysiology. He had found that disturbances in the behavior of his dogs occurred when the excitatory and the

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inhibitory stimuli were made similar in their physical properties, e.g., when the tone representing food to the hungry dog approached in pitch the tone with which the dog never received food—the so-called conflict between excitation and inhibition.

Pavlov's choice of the salivary gland as an index of higher nervous activity was a fortunate one for the early work with conditional reflexes, but equally unfortunate as a basis for medicine and psychosomatic relationships. Salivation, having few connections in the body except with the ingestion of food or of irritating substances, was ideal as a barometer for cerebral activity. But salivary function has little interest for medicine. Perhaps for this reason Pavlov's concepts have not been readily adopted in medicine—because of the general notion that the conditional reflex could be comprehended by the statement that "you ring a bell and the dog secretes saliva."

Pavlov was well aware of the fluctuations of the cardio-respiratory functions accompanying the conditional reflex, but he did not use this function as a measure because of the multitudinous connections of this system with other physiological functions.

I. *Use of Cardiovascular Function*

In our laboratories, at the Johns Hopkins University and in the VA Hospital at Perry Point, the cardiovascular functions have been systematically studied for the past two decades (*a*) because of the increasing importance of this system in human pathology, and (*b*) because the cardiovascular responses reveal inner mechanisms at the basis of neurotic and psychotic development which cannot be readily seen in other physiological systems. Certain properties of the cardiovascular system make it especially useful in the above studies. First, one or another aspect of cardiovascular function may be the most delicate objective record of new relationships formed to the environment. Second, the cardiovascular reflexes obey the general laws established by Pavlov for conditional reflexes, but there are important differences. These differences may be responsible for cardiovascular pathology and, as well, may reveal a mechanism of psychotic development. Cardiovascular functions such as heart rate and blood pressure are ordinarily less open to inspection by the subject—*viz.*, not so evident in consciousness as salivation. But the fact that this function may be unconscious does not mean that it cannot become a conditional reflex (1).

A study of cardiovascular reflexes has given us a special insight into the action of the nervous system, the establishment of neurotic and psychotic states, and special pathological cardiovascular functions such as tachycardia and hypertension.

In order to encompass the range of cardiovascular changes in more than one species, we have studied cardiac conditioning in penguins, opossums, cats, puppies, and dogs, as well as in the human being. Most of our work has been done in the dog, which has especial advantages for the study of cardiac conditional reflexes because of the ease of measurements and his adaptability, as well as his responsiveness to the human being. There are definite species variations, the dog ranking high as a cardiovascular reactor.

In a human being, although we may not see as marked cardiovascular changes to the usual type of Pavlovian conditioning (reinforcement with shock or food), definite responses in both rate and blood pressure to the elaborations of emotionally charged conditioning are evident. He has, of course, a much greater capacity for widespread generalization than any other animal. In the human there are also involved symbols of language, the so-called second signaling system of Pavlov (2).

II. *Criterion for Conditional Reflex Formation*

Our investigations have shown that consciousness indeed plays no role in the establishment of the conditional reflex; autonomic functions, such as urinary, gastric, or pancreatic secretions, are as readily conditioned as the somatic gross movements of the body. The criterion is not whether the function is autonomic or somatic, unconscious or conscious, but whether it has a representation in the central nervous system. The same reaction may be at one time conditionable and at another time not, depending upon whether it involves peripheral excitation or central. Thus, gastric secretion as a component of food excitation can be easily conditioned, but gastric secretion evoked by histamine injection, which acts directly on the peptic glands, is not conditionable; tachycardia as a component of hunger or pain is conditionable, but not heart rate changes either to acetylcholine or atropine injection, both of which modify the heart rate through peripheral action; hyperglycemia as a component of fear can be conditioned, but not when it is produced through injection of adrenalin, which acts on the tissues independently of central nervous system involvement. Every function which we have tested can, when it involves central nervous

system excitation, be established as a conditional reflex, but the same function produced by peripheral action alone can never be made into a conditional reflex.

The action of some agents and drugs is complex, consisting of events mediated through the central nervous system, as well as those actuated only by peripheral action or on the nerve endings or on the tissues directly. This leads to the concept of *fractional* conditioning, in which we get a part of the action formed as a conditional reflex but not the whole action (3).

The fact that blocking of a muscular action in the conditional reflex, either by paralysis of the peripheral nerve or by the action of curare, does not prevent the cardiac increase seen in the conditional reflex indicates that central excitation and not muscular activity or gross movement is the responsible factor in the increased heart rate present in the cardiac conditional reflex.

III. *The Role of the Person*

The routine recording of cardiovascular alterations in our dogs has revealed to us the unusual effect of one individual on another, whether dog on dog or human on dog, etc. This is what we call the *effect of person.*

We are not the first to recognize this influence. It has been noted throughout the ages by scientists as well as by philosophers and poets, and is exemplified by the insect, as well as by Romeo serenading Juliet, the mother tending her offspring, or the bereaved at the grave.

Darwin notes the wide prevalence of the effect of tactile stimulation in nature, plus a "strong desire to touch the beloved person. . . . Dogs and cats manifestly take pleasure in rubbing against their master and in being rubbed. . . . Monkeys delight in fondling and in being fondled." He mentions kissing, rubbing noses, patting of the arms, etc. as human expressions, regarding kissing as innate "insofar as it depends on the pleasure derived from contact with the beloved person." He also describes a patient with heart disease and an extremely irregular pulse which "invariably became regular as soon as my Father entered the room" (4).

While not agreed as to whether this desire for social contact is innate and constitutes a homeostatic drive, psychologists are well aware of its importance to mental health; much clinical data is accumulating on the effects of personal isolation and the implications of family environment for subsequent intellectual and personality growth.

This, of course, is an influence recognized in psychiatry, as well as generally, but it has lacked scientific validation. Specific instances have been recognized by Freud as "transference," and on a wider scale by Sullivan, Whitehorn, and others as interpersonal relations. But the data from the whole range of the animal kingdom attest to the universality of the Effect of Person. The "imprinting" of Conrad Lorenz and the study of infant lambs by Blauvelt in Liddell's laboratory illustrate the special susceptibility of the very young to the formation of stable conditional reflexes—perhaps, like the schizokinetic cardiac conditional reflexes, unmodifiable in later life (5).

Pavlov saw the effect of the experimenter in his early studies as a factor in the conditional reflex. For this reason he took special precautions to exclude the dog from the investigator. In his report in 1916 he began to analyze this effect. He thought that in special dogs there existed the "guarding" reflex, which made them especially susceptible to the presence of the human being. He found that sometimes the presence of the person was more powerful than the food conditional reflex. He also noted that certain people had a more powerful influence on the dog than other people. In 1925 Pavlov described this influence as a "social" reflex. He found that the clothing of the person could substitute for the person himself (6).

These studies of Pavlov are important in his early recognition of the effect of person. However, he limited this to certain people and certain dogs, and he did not, like Darwin, recognize it as a universal principle.

It is regrettable that the precautions of Pavlov in isolating the experimenter from the subject are not rigorously followed today, even in Russia. This isolation is extremely important in the study of the conditional reflex.

IV. *Experimental Neurosis*

Our previous work on experimental neurosis shows that many procedures other than the classical collision of excitation and inhibition of Pavlov could produce marked disturbances of behavior. The symptoms developed depend more upon the type of animal than upon the procedure. There is in general a developing spread of the original focus of disturbance to involve many visceral systems—respiratory, cardiovascular, general activity, and sexual—although these systems were not involved in the original disturbance. The factor of "organ susceptibility" as mentioned by Adler may be involved (7, 8).

In two neurotic dogs, "Nick" and "V3," both of which we have studied for fourteen years, the effect of person has been especially strong. Aside from the more pronounced bradycardia and bradypnea accompanying petting in these dogs, special effects appear. Mere presence of a person appears to be a conditional stimulus for the bradycardia and bradypnea to petting, potent enough in "Nick" to inhibit completely the marked respiratory changes usually evoked by an anxiety-producing stimulus and strong enough in "V3" to decrease heart rate from 140–180 while the dog is alone to 60–70 while a person is present. In addition, on several occasions petting has produced sudden cardiac arrest of 6–8 seconds in "V3" as well as a profound drop in systolic blood pressure—from 140 to 75, remaining low for 8 minutes (unpublished experiments of Newton).

The mechanisms represented in schizokinesis and autokinesis may underlie some of the Freudian concepts. What Freud attributed to superego, ego, and id, to the conscious and unconscious, perhaps finds a parallel in the split between the more obvious superficial reactions and the inner, unseen, and specifically unfelt. The developments in adulthood on the basis of early infantile experiences seem to fall into the category of autokinetic phenomena. What Freud had to say about fixations, Oedipus complexes, transference, and all those relationships emanating from sex may be nothing more than special cases of the universal principle of Effect of Person.

A comparative study of the cardiac conditional reflexes with the more specific ones such as the salivary and the motor reveals interesting phenomena. First, there is a general parallel in the quantitative relationships between the intensity of the stimulus (conditional stimulus and unconditional stimulus), latent period, etc. However, the cardiac component of the conditional reflex forms very much more quickly than either the salivary or the motor components—often after one reinforcement. Previous laboratory experiments indicated that the motor and salivary may not appear until thirty or more repetitions. This early formation of the cardiac conditional reflex is more in keeping with subjective experience, where a single episode, if powerful, may result in a lasting impression or tendency to respond. Paradoxically, and to our amazement, the cardiac conditional reflex is much more stable and lasting than are the more specific and obvious components of the conditional reflex. In some dogs the heart rate change may last for five or ten years; and even where there is active extinction to eliminate the conditional reflex, resulting in inhibition, the dog may

retain cardiac acceleration in the presence of the stimulus to the same extent that he did before the extinction. Thus, in a dog which had been fed with a bell, resulting in an increase in heart rate during the bell of thirty beats per minute, the salivation to the bell was reduced to zero after a few days' practice of giving the bell without the food, but the cardiac acceleration to the bell remained the same—even when it was tested five years later and the dog had never been fed with the bell during this period. Dogs vary widely in this difference in speed of formation of the motor and cardiac components of the conditional reflex; they also vary widely in the duration of the retention of the cardiac component after extinction.

Recent experiments (9) have revealed that in normal dogs the heart rate conditional reflex is regularly found after only one reinforcement: viz., after accompanying a signal only once by an unconditional reflex such as a faradic shock of moderate intensity, while there was no accompanying motor reflex. Furthermore, though the signal was then repeated for many trials (up to sixty) without the shock, the heart rate increase did not disappear—it could not be extinguished. Ordinarily, when the motor or the salivary conditional reflexes are formed, they can be readily extinguished by the above procedure to which the cardiac conditional reflex is resistant. Thus, even in normal dogs we find this marked basis for schizokinesis—quick development and, paradoxically, a very stable and resistant response. The organism has acquired easily a new visceral function (cardiac) of which it can rid itself only with great difficulty.

Schizokinesis is the name that we give to this quality of discrepancy between the more general emotional components of the conditional reflex and the specific obvious ones. Extending the concept of schizokinesis, the term may be used to indicate a maladaptation of the organism to its environment; with some of the physiological functions of the organism in adaptation to the milieu, it may appear superficially undisturbed, but underneath, in the autonomic components of the response, there may be violent agitation. Here we may find an explanation of the inner upheavals to past events not reflected on the surface, and even out of conscious memory. On this basis there may be a development of hypertension to painful experiences which may have passed out of conscious memory. In death we see the final expression of this maladaptation, this schizokinesis

in the organism, when it gives up the battle to maintain itself as an integrated unit (10).

Autokinesis. In several decades of studying neurotic as well as normal dogs, we have been struck by the changes occurring over a long period, based on past experiences but developing in the absence of repetition of the original experience. Thus, in "Nick" a whole train of neurotic symptoms appeared, related to the original stress, but developing and becoming worse during three years when the animal was removed from this environment. Even more severe symptoms developed in "V3." These are examples of negative autokinesis. But there is also evidence of positive autokinesis: e.g., when a single therapeutic conference or some experience in the life of an individual has a profound and lasting effect for good. In the normal animal, autokinesis can be seen in the elaboration of new relationships among the original excitatory foci, modifying or completely changing the relationship between the conditional reflexes (5, 11).

This is a circumscribed view of autokinesis, but one may conclude that there is a normally occurring basic principle of inner development—that this is a basic physiological law. Besides the examples from our laboratory, which provide striking contrasts because we have quantitative measurements for comparison and precise stimuli, there are a host of other examples from the laboratories of other workers, as well as from ordinary life. Embryology itself is an example of development determined from within, changes depending upon the internal structure more than on the external environment.

Recently there has been some evidence from neurophysiology of changes in the brain which support the concept of autokinesis, especially from the work of Eccles and Jerzy Rose. After destruction of certain cortical cell layers, Rose found that the processes from adjacent cells grow to make new connections across the layer of destroyed tissue (12).

In the study of the ataraxic drugs, evaluation of the effect of person is aided by recording the cardiovascular and other autonomic alterations. These may reveal what is the effect of person and what is due to the drug itself; also, which of the responses are conditional reflexes. In our work we have found, e.g., that meprobamate may have a beneficial effect on certain cardiac states by reducing the cardiac component of both the orienting reflex and the conditional reflex, while leaving the motor components undisturbed (11).

To extend the concept of Pavlov that drugs have different effects on

different types (temperaments), the therapeutic action of drugs may be explained by the fact that the drug acts on the *type* of individual rather than on the disease, but that certain types are prone to develop certain symptoms—anxious, depressive, schizophrenic.

Homeostasis is a cardinal principle in the maintenance of life in all living structures. The imperfections of this equilibrating tendency are seen in the laboratory in the primitive discrepancy between the adaptive functions in the supporting cardio-respiratory systems and the specific responses—*schizokinesis*. The organism having once passed through an experience perhaps can never be reduced to its pre-experimental state; inhibition is not complete but partial (fractional), often leaving the organism to react in certain autonomic ways to its detriment, while it appears superficially in adaptation. *Autokinesis* may be either negative or positive, carrying the organism downward to its destruction, or upward to a better adjustment. Furthermore, these autokinetic developments may occur from elaborations within the nervous system, independently of the current milieu, but related to the traces of what has gone on before.

Studies of behavior have for several generations emphasized the importance of the external environment from the time of John Locke and Rousseau down to the reflexology of Bechterev, the conditional reflex of Pavlov, and the behaviorism of Thorndike and Watson. These schools have provided us with a wealth of factual material. But students of behavior, especially the higher forms, have been confronted with the fact that although actions obey laws, they are seldom exact duplicates even though the external milieu and the external stimuli are constant. But there has been no general formulation of another principle. Autokinesis not only recognizes an *internal* environment (investigated especially by Claude Bernard), but it admits of interaction among the foci of excitations, the traces of past stimulations, leading to changed internal relationships. On the functional side, we can clearly see this—and there is some anatomical evidence, as in the work of Jerzy Rose. Here lies a tremendous new field for scientific exploration, a more difficult one than the external relationships, but one which lures us to unwrap further the mystery of our psychical life.

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